Studies on the Egg Parasites of the Rice Grasshoppers, *Oxya japonica* WILLEMSE and *O. velox* FABRICIUS (VIII) *

Especially on the Life-cycle and the Postembryonic Development of the Egg Parasites, *Scelio muraii* WATANABE and *S. tsuruokensis* WATANABE**

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In the fourth report, the author recorded on the number of times of the occurrence and the longevity of adults of both the species (MURAI, 1957c). In that paper, the author described on the duration from the parasitization to the emergence of both the species, *i. e.*, the period of immature stage, but the length of each developmental stage passed within the *Oxya* eggs was not described.

In the present paper, the author details with the life-cycle which lays emphasis on each developmental stage and the informations in regard to the postembryonic development of both the species.

Before going further, the author wishes to express his grateful acknowledgement to Dr. Noboru ABE for the kind guidance given to the author during the course of the present study, and to Dr. B. P. UVAROV of Anti-Locust Research Centre, England, and Dr. C. P. CLAUSEN of Department of Biological Control, University of California, U. S. A. for their valuable advices.

Materials and Methods

1) The life-cycle

The adults of both the species, emerged in the middle of August, 1957 (this season agree with the period of emergence on the field), were continuously parasitized to the refrigerated *Oxya* eggs (pods) and produced the progeny in late of September. Those progeny were immediately parasitized to the newly deposited *Oxya* eggs and its parasitized egg pods were protected under the normal temperature in the laboratory until August, 1958 (cf. Fig. 1). And the observations of the development of both the species in host eggs were performed with the dissection.

Moreover, the table of the life-cycle of both the species was obtained by rearing many individuals and the field observations from September, 1953 to August, 1958.

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The temperature was recorded with the self-recording thermometer.

2) The postembryonic development

From August, 1957 to August, 1958, the postembryonic development of both the species was investigated with the dissection of the parasitized host eggs. The size of the body was measured by micrometer. And in case of the observations of the morphological characters, the vital staining was occasionally performed by neutral red.

The details of the experimental methods are given on each of such occasions.

Results

1) The life-cycle of *Scelio muraii* and *S. tsuruokensis* (cf. Plates Ⅰ～Ⅳ)

On August 13, 1957, the adults of both the species were parasitized to the refrigerated *Oxya* eggs (pods), and the new adults which emerged from those egg pods in late of September, *i. e., Scelio muraii* was emerged on September 26 and *S. tsuruokensis* was emerged on September 24, were continuously parasitized to the fresh *Oxya* egg pods on September 26 (cf. Fig. 1).

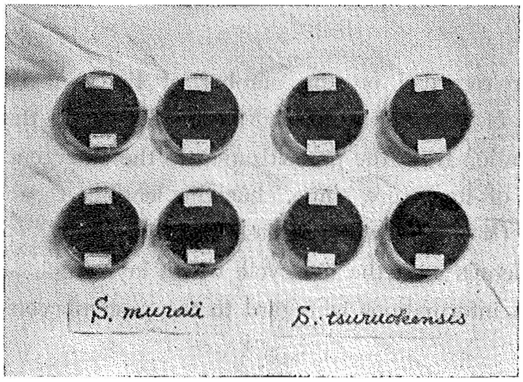

Fig. 1. Showing the rearing of the parasitized egg pods.

The life-cycle which lays emphasis on each developmental stage is shown in Tables 1 and 2.

Table 1
The length of each developmental stage of *Scelio muraii* and *S. tsuruokensis* which parasitized on August 13, 1957

Sp. and temp. \ Item		Length of egg stage (days)	Length of larval stage (days) 1st	2nd	3rd	Length of pupal stage (days)	Length of adult stage (days)	Total (days)
Scelio muraii		3		19		22	(8)*	44 (52)
			8	7	4			
Mean temp. (°C)	Max.	25.5	29.8	27.5	22.8	22.8	(19.7)	24.7 (24.2)
	Min.	23.4	24.7	24.3	19.9	19.0	(15.5)	22.7 (20.5)
	Av.	24.5	27.3	25.9	21.4	20.9	(17.6)	23.7 (22.4)
S. tsuruokensis		3		19		20	(8)*	42 (50)
			8	7	4			
Mean temp. (°C)	Max.	25.5	29.8	27.5	22.8	23.3	(19.7)	25.2 (24.4)
	Min.	23.4	24.7	24.3	19.9	19.4	(16.0)	21.4 (20.7)
	Av.	24.5	27.3	25.9	21.4	21.4	(17.9)	23.3 (22.6)

Note : The host eggs which parasitized by both the species were all the same in embryonal development.

* The length of the adult stage was piled on egg stage of the next generation.

Table 2
The length of each developmental stage of *Scelio muraii* and *S. tsuruokensis* which parasitized on September 26, 1957.

Sp. and temp. \ Item	Length of egg stage (days)	Length of larval stage (days) 1st	2nd	3rd	Length of pupal stage (days)	Length of adult stage (days)	Total (days)
Scelio muraii	5	284			12	(8)*	301 (309)
		269	11	4			
Mean temp. (°C) Max.	20.0	14.4	24.7	25.7	25.5	(25.0)	15.6 (15.8)
Min.	15.6	8.2	21.6	22.2	23.1	(22.6)	9.6 (9.9)
Av.	17.8	11.3	23.2	24.0	24.3	(23.8)	12.6 (12.9)
S. tsuruokensis	5	287			11	(7)*	303 (310)
		271	12	4			
Mean temp. (°C) Max.	20.0	14.5	24.6	25.4	25.2	(25.6)	15.7 (15.9)
Min.	15.6	8.2	21.7	22.3	22.3	(22.9)	9.7 (10.0)
Av.	17.8	11.4	23.2	23.9	23.8	(24.3)	12.7 (13.0)

Note : The host eggs which parasitized by both the species were all the same in embryonal development.
* The length of the adult stage was piled on egg stage of the next generation.

Therewith, the author obtained the table of the life-cycle of both the species on the field by rearing many individuals and the field observations from September, 1953 to August, 1958, as is shown in Table 3.

Table 3
The life-cycle of *Scelio muraii* and *S. tsuruokensis* on the field

Generation \ Month	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
One generation in a year	— — —	— — —	— — —	— — —	— — —	— — —	— — —	— — — +	— + + ○○○ ●●● — —	— — —	— — —	— — —
Two generations in a year	— — —	— — —	— — —	— — —	— — —	— — —	— — — +	— + + ○○○ ●●● — — +	— + + ○○○ ●●● — —	— — —	— — —	— — —

● : Eggs, — : Larvae, + : Pupae, ○ : Adults

2) The postembryonic development of *Scelio muraii* and *S. tsuruokensis* (cf. Plates I ～ IV)

The size of the body of each developmental stage of both the species, parasitized on August 13 and September 26, 1957, is shown in Tables 4 and 5, and the morphological characters and the behaviours of those are as follows :

a) The larva

i) The first instar (Pl. I . *C～H*, Pl. III. *B*)

The first instar larva on early days, hatched from the eggs (translucent white in colour, slender with the line of demarcation between the stalk and main body not distinct. Pl. Ⅰ. *A*～*B*, Pl. Ⅲ. *A*) is translucent white in colour, sac-like in form, consists of cephalothorax and abdomen (protopod larva). The antennal processes are large and conical, widely spaced, arise immediately above the bases of the mandibles. The mandibles are external, widely spaced, exceedingly large, curved, sharply pointed. The mouth parts are situated on the median ventral line of the cephalothorax and opened between the mandibles. The abdomen is more or less globular in form, bears about 50 strong bristles in double arising dorso-laterally (near the anterior margin of the abdomen) and elongated tapering tail-like appendage (caudoventral horn or tail) extending forward beneath the body almost to the head.

The first instar larva is capable of considerable movement. The ring of the long bristles on the abdomen may be raised perpendicularly and a locomotory function is ascribed to them. The mandibles may be moved in front of the mouth parts and also the caudoventral horn or tail may be moved in a wide arc in the vertical plane. Those movements played an important part for bringing food materials to the mouth or disorganizing the contents of the host egg.

The first instar larva is not possessed of the tracheal system or spiracles and the digestive tract is blinded. The hibernation is played in this stage.

The differentiation of both the species in this stage, it seems, is distinguished by the process of distal portion of the caudoventral horn or tail.

ii) The second instar (Pl. Ⅰ. *I*～*J*, Pl. Ⅲ. *C*)

The second instar larva on early days is translucent white in colour, cylindrical in form, lacked the legs (apodous larvae). Also, this instar larva on early days is not possessed of the segments, but on late days the segments are distinctly segmented, *i. e.*, 11 segments are counted.

The second instar larva moved by creeping in the host egg, attacked the body of embryo, and the entire egg contents are eventually consumed.

The possession of the tracheal system or spiracles is not recognized.

Table 4

The size of the body of each developmental stage of *Scelio muraii* and *S. tsuruokensis* which parasitized on August 13, 1957

Scelio muraii				*S. tsuruokensis*			
Date of observation	Stage of developed	Length of body (mm)	Width of body (mm)	Date of observation	Stage of developed	Length of body (mm)	Width of body (mm)
Aug. 13, 1957	Egg	0.86	0.24	Aug. 13, 1957	Egg	0.86	0.26
Aug. 15, 1957	Egg	1.14	0.26	Aug. 15, 1957	Egg	0.97	0.26
Aug. 16, 1957	Larva (1st instar)	0.60	0.38	Aug. 16, 1957	Larve (1st instar)	0.68	0.41
Aug. 23, 1957	Larva (1st instar)	1.48	0.64	Aug. 23, 1957	Larve (1st instar)	1.38	0.62
Aug. 24, 1957	Larva (2nd instar)	2.35	1.45	Aug. 24, 1957	Larve (2nd instar)	2.25	1.37
Aug. 30, 1957	Larva (2nd instar)	4.23	1.43	Aug. 30, 1957	Larve (2nd instar)	4.34	1.42
Aug. 31, 1957	Larva (3rd instar)	3.83	1.43	Aug. 31, 1957	Larve (3rd instar)	4.09	1.35
Sept. 4, 1957	Pupa	4.38	1.28	Sept. 4, 1957	Pupa	4.15	1.15
Sept. 26, 1957	Adult	4.32	1.02	Sept. 24, 1957	Adult	4.26	1.05

Note. : The body length of 1st instar larva was measured except the antennal process and caudoventral horn or tail.

Table 5

The size of the body of each developmental stage of *Scelio muraii* and *S. tsuruokensis* which parasitized on September 26, 1957

Scelio muraii				*S. tsuruokensis*			
Date of observation	Stage of developed	Length of body (mm)	Width of body (mm)	Date of observation	Stage of developed	Length of body (mm)	Width of body (mm)
Sept. 26, 1957	Egg	0.84	0.22	Sept. 26, 1957	Egg	0.82	0.22
Sept. 30, 1957	Egg	1.15	0.25	Sept. 30, 1957	Egg	0.94	0.20
Oct. 1, 1957	Larva (1st instar)	0.66	0.34	Oct. 1, 1957	Larva (1st instar)	0.68	0.38
Nov. 3, 1957	Larva (1st instar)	0.76	0.37	Nov. 3, 1957	Larva (1st instar)	0.77	0.37
Dec. 3, 1957	Larva (1st instar)	0.76	0.37	Dec. 3, 1957	Larva (1st instar)	0.76	0.37
Jan. 9, 1958	Larva (1st instar)	0.76	0.37	Jan. 9, 1958	Larva (1st instar)	0.77	0.37
Feb. 4, 1958	Larva (1st instar)	0.78	0.37	Feb. 4, 1958	Larva (1st instar)	0.78	0.37
Mar. 8, 1958	Larva (1st instar)	0.76	0.37	Mar. 10, 1958	Larva (1st instar)	0.78	0.38
Apr. 16, 1958	Larva (1st instar)	0.76	0.38	Apr. 16, 1958	Larva (1st instar)	0.76	0.38
May 6, 1958	Larva (1st instar)	0.77	0.43	May 23, 1958	Larva (1st instar)	0.77	0.45
June 5, 1958	Larva (1st instar)	0.88	0.43	June 5, 1958	Larva (1st instar)	0.78	0.45
June 26, 1958	Larva (1st instar)	1.50	0.65	June 28, 1958	Larva (1st instar)	1.33	0.65
June 27, 1958	Larva (2nd instar)	2.22	1.42	June 29, 1958	Larva (2nd instar)	2.31	1.36
July 8, 1958	Larva (3rd instar)	3.78	1.40	July 11, 1958	Larva (3rd instar)	3.81	1.30
July 12, 1958	Pupa	4.28	1.25	July 15, 1958	Pupa	4.36	1.27
July 24, 1958	Adult	4.23	0.98	July 26, 1958	Adult	4.28	1.00

Note : The body length of 1st instar was measured except the antennal process and caudoventral horn or tail.

iii) The third instar (Pl. I. *K*~*L*, Pl. III. *D*)

The third instar larva is similar in form to the second instar larva, but it may be readily distinguished by presence of the spiracles, situated on the last two thoracic and abdominal segments.

The third instar larva on late days is rested in the host egg.

b) The prepupa and pupa (Pl. I. *M*~*R*, Pl. III. *E*~*H*)

The prepupa is narrowed near the first and second segments of the abdomen.

The pupa on early days is translucent white in colour except the compound eye which is light brown, apparently separated between the tergum and sternum. The foveately punctate of the head, thorax and the striate of the abdomen is not clear. But the colour and structure changes gradually to the same one of the adult.

The excrements are light orange in colour.

In pupa, the differentiation of both the species is distinctly distinguished than that of the first instar. Namely, the first tergite of *Scelio muraii* is little longer than the breadth at base and the scutellum is unarmed, whereas that of *S. tsuruokensis* is distinctly shorter than the breadth at base and the scutellum is armed.

Also, the differentiation of the male and female is distinguished by form of the antennae, *i. e.*, the antennae of the female are 12-jointed and those of the male are 10-jointed.

C) The adult (Pl. I. *S*~*Y*, Pl. IV. *I*)

The adult is black in colour and easily distinguished by following points except the points of the differences in pupal stage. Namely, in *Scelio muraii* its legs are reddish yellow, veins dark brown, stigmal vein slender, 2nd tergite hardly impressed on basal half, whereas in *S. tsuruokensis* its legs are yellow, veins darker, stigmal vein stout, 2nd tergite distinctly impressed on basal half.

As for the activities, habits, etc. of the adult, it has been recorded in details again and again in the previous reports.

Consideration

1) The life-cycle

The life-cycle of genus *Scelio* which lays emphasis on each developmental stage is unknown up to the present, because the observations of the development of the immature stage passed within the host eggs enclosed the egg pod are very difficult.

As is seen in Tables 1 and 2, in the life-cycle of *Scelio muraii* and *S. tsuruokensis* no remarkable difference is seen, when the parasitized host eggs, all the same in embryonal development of the host, are reared under the similar environmental conditions.

In case of this investigations, the number of times of the occurrence of adult is undoubtedly twice and roughly corresponds to the Table 3 (two generations in a year). But such life-cycle is limited in case of the eggs deposited by grasshoppers from August in the field (MURAI, 1957c). And the majority of host eggs are, in general, deposited from September to October in Japan (MURAI, 1954), so that the life-cycle becomes one generation in a year.

This fact suggests that the life-cycle changes by period of the parasitization, environmental conditions after parasitization, etc.

The hibernation is held in the larval stage (first instar) and the insects of this instar may stand the low temperature. On the other hand, the author attempted the experiments of the hibernation in other larval (2nd and 3rd instar) and pupal stage, but each insect could not be hibernated.

The duration from the parasitization to the emergence of *Scelio pembertoni* belonging to the same genus was 25～35 days in Serdang and Kuala Lumpur, Selangor, F. M. S. (PEMBERTON, 1933).

2) The postembryonic development

The postembryonic development of genus *Scelio* is unknown up to the present.

As is seen in Tables 4 and 5, in the postembryonic development of both the species no remarkable difference is seen. But it seems that, both the species may be scarcely distinguished in the morphological characters of the first instar and after pupation. Therefore, the relationship of both the species is in need of investigations in future.

As is seen in Tables 1, 2, 4 and 5, the velocity of the development of both the species changes by period of the parasitization, extent of the development of host embryo of those days, environmental conditions (especially the temperature), etc. after parasitization.

This fact, *i. e.*, the changes of the duration from the parasitization to the emergence, is considered in datails again and again before now.

The morphological characters of first instar larva of both the species are very much resembled to those of *Scelio pembertoni* (PEMBERTON, 1933), but the number of the strong bristles arising dorso-laterally are distinctly differs, *i. e.*, *Scelio muraii* and *S. tsuruokensis* bears about 50, whereas *S. pembertoni* bears about 16.

Summary

1) In the life-cycle of both the species, no remarkable differences were seen, when the parasitized host eggs, all the same in embryonal development of host, were reared under the similar environmental conditions (cf. Tables 1 and 2). But it seems that, the life-cycle changes by the period of the parasitization, environmental conditions (especially the temperature) after parasitization, etc. in the field. Hence, the majority of individuals hold one generation in a year and some individuals, *i. e.*, those emerged from the host eggs in August and parasitized to the fresh host eggs within a same month, hold two generations in a year (cf. Table 3).

The hibernation is held in the larval stage (first instar).

2) In the postembryonic development of both the species, no remarkable differences were seen (cf. Tables 4 and 5). But it seems that, both the species may be distinguished in the morphological characters of the first instar larva and after pupation (cf. Plates Ⅰ～Ⅵ). The relationship of both the species is, therefore, in need of investigations in future.

The velocity of the development of both the species changes by the period of the parasitization, extent of the development of the host embryo of those days, environmental conditions (especially the temperature), etc. after parasitization.

References

1) CLAUSEN, C. P. (1940) : Entomophagous Insects. New York. 249–257.

2) MURAI, S. (1954) : Studies on the Egg Parasites of the Rice Grasshoppers, *Oxya japonica* WILLEMSE and *O. velox* FABRICIUS (Ⅰ) Especially on the Activity Fluctuation of Adults of the Egg Parasites and the Environmental Conditions. Bull. Yamagata Univ. (Agr. Sci.), **2**. 1 : 1–13. (In Japanese with a summary in English)

3) —— (1957a) : *Ibid* (Ⅱ) Especially on the Emergence, Seasonal Prevalence, Rate of the Appearance and the Sex Ratio of Adults of the Egg Parasites, *Scelio muraii* WATANABE and *S. tsuruokensis* WATANABE. *Ibid.* **2**. 3 : 31–40.

4) —— (1957b) : *Ibid* (Ⅲ) Especially on the Activity of the Copulation, Oviposition and the Percentage of the Parasitism of Adults of the Egg Parasites, *Scelio muraii* W. and *S. tsuruokensis* W. *Ibid.* **2**. 3 : 41–49.

5) —— (1957c) : *Ibid* (Ⅳ) Especially on the Number of Times of the Occurrence and the Longevity of Adults of the Egg Parasites, *Scelio muraii* W. and *S. tsuruokensis* W. *Ibid.* **2**. 3 : 51–55.

6) —— (1958) : *Ibid* (Ⅴ) Especially on the Parthenogenesis of the Egg Parasites, *Scelio muraii* W. and *S. tsuruokensis* W. *Ibid.* **2**. 4 : 153–156.

7) —— (1959a) : *Ibid* (Ⅵ) Eepecially on the Power of the Oviposition and the Distribution Pattern

in Host Eggs of the Egg Parasites, *Scelio muraii* W. and *S. tsuruokensis* W. *Ibid.* **3**. 1 : 65–72.
8) —— (1959b) : *Ibid* (Ⅶ) Especially on the Selection and the Finding of the Host of the Egg Parasites, *Scelio muraii* W. and *S. tsuruokensis* W. *Ibid* **3**. 1 : 73–79.
9) PEMBERTON, C. E. (1933) : Introduction to Hawaii of Malayan Parasites (Scelionidae) of the Chinese Grasshoppers, *Oxya chinensis* (THUN.) with Life History Notes. Proc. Haw. Ent. Soc., 8 : 253–264.
10) UVAROV, B. P. (1928) : Locusts and Grasshoppers. Imp. Bur. Ent., London. 113–116.

Explanation of Plates Ⅰ – Ⅱ (*Scelio muraii* WATANABE)

Fig. *A*. Ovary. ×ca. 20
Fig. *B*. Eggs. ×ca. 18
Fig. *C*. Larva of first instar on early days (lateral aspect). ×ca. 40
Fig. *D*. Larva of do (ventral aspect). ×ca. 40
Fig. *E*. Larva of do on late days (lateral aspect). ×ca. 24
Fig. *F*. Larva of do (ventral aspect). ×ca. 24
Fig. *G*. Distal portion of caudoventral horn or tail.
Fig. *H*. Base of bristles.
Fig. *I*. Larva of second instar on middle days. ×ca. 16
Fig. *J*. Larva of do on late days. ×ca. 13
Fig. *K*. Mouth-parts of third instar.
Fig. *L*. Larva of do (lateral aspect). ×ca. 13
Fig. *M*. Prepupa. ×ca. 10
Fig. *N*. Prepupa (lateral aspect). ×ca. 10
Fig. *O*. Pharate. ×ca. 10
Fig. *P*. Pupa. ×ca. 10
Fig. *Q*. Pupa on late days. ×ca. 10
Fig. *R*. Pupa of do (lateral aspect). ×ca. 10
Fig. *S*. Female adult. ×ca. 17
Fig. *T*. Male adult. ×ca. 17
Fig. *U*. Antenna of female. ×ca. 25
Fig. *V*. Ovipositor of do. ×ca. 6
Fig. *W*. Distal portion of ovipositor. ×ca. 40
Fig. *X*. Antenna of male. ×ca. 25
Fig. *Y*. Genitalia of do. ×ca. 60

Explanation of Plates Ⅲ – Ⅳ (*Scelio tsuruokensis* WATANABE)

Fig. *A*. Eggs. ×ca, 20
Fig. *B*. Larva of first instar. ×ca. 40
Fig. *C*. Larva of second instar. ×ca. 10
Fig. *D*. Larva of third instar. ×ca. 13
Fig. *E*. Prepupa. ×ca. 10
Fig. *F*. Pharate. ×ca. 10
Fig. *G*. Pupa on early days. ×ca. 10
Fig. *H*. Pupa on middle days. ×ca. 10
Fig. *I*. Female adult. ×ca. 17

摘　　　要

イナゴ卵寄生蜂に関する研究（第8報）
特に寄生蜂ムライクロタマゴバチ及びツルオカクロタマゴバチの生活環と後胚子発生について

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1）両卵寄生蜂の生活環は胚子の発育同様の寄主卵を供試し，同様の環境条件下で飼育した場合には，殆んど差異を認めない（第1表及び第2表）．

しかし，野外においては寄生の時期，寄生後の環境条件（特に温度）などによつて生活環は変化するようで，大部分の個体は年に1世代しか経過しないが，8月中に羽化して直ちに寄主卵に寄生を完了した個体は年に2世代を経過する（第3表）．

越冬は第1令幼虫でなされる．

2）両卵寄生蜂とも，その後胚子発生は極めて類似しており（第4，5表及び Plates Ⅰ～Ⅳ），各ステージの体長，体巾，活動習性などにおいては著しい差異を認めることは出来なかつた．

ただ，現在のところでは，第1令幼虫及び蛹化後の形態的特徴において，僅かに両卵寄生蜂の区別がつけられる程度のようである．したがつて，将来更に詳しい両卵寄生蜂の未成熟ステージでの区別点と，両種の血縁関係などについて調査する必要があるものと思われる．

一方，両卵寄生蜂の発育速度は，寄生の時期，寄生当時の寄主胚子の発育状態，寄生後の環境条件（特に温度）などによつて影響される．

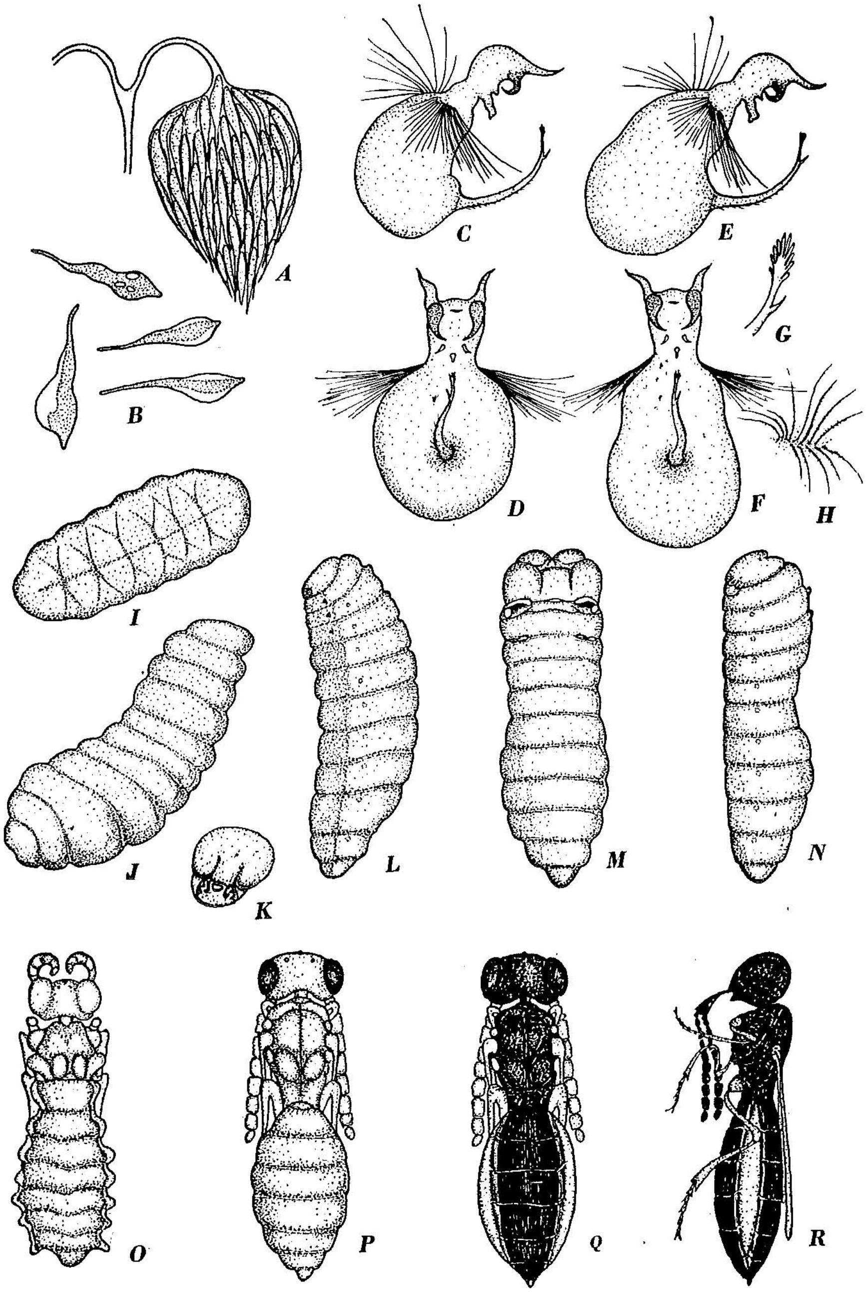
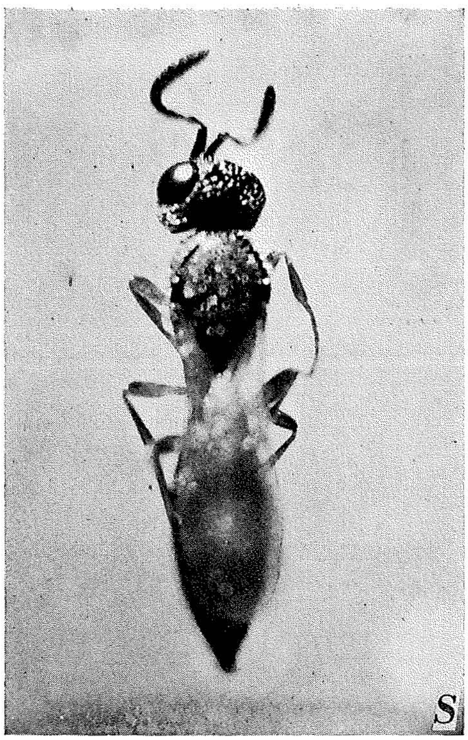
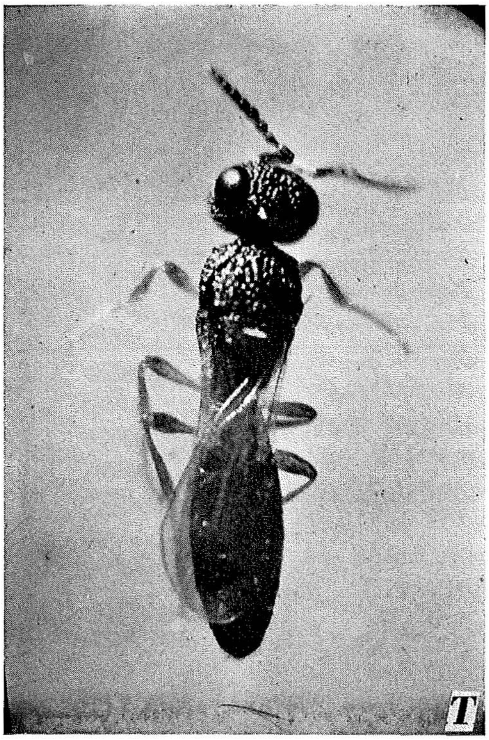


Plate Ⅰ. *Scelio muraii* WATANABE





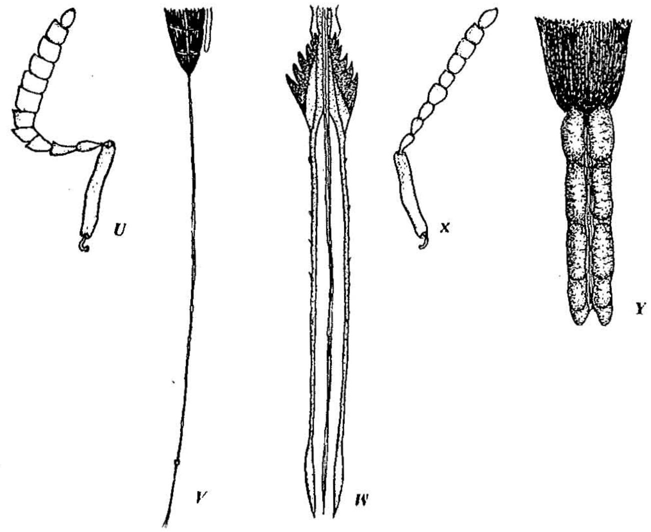


Plate Ⅱ. *Scelio muraii* WATANABE

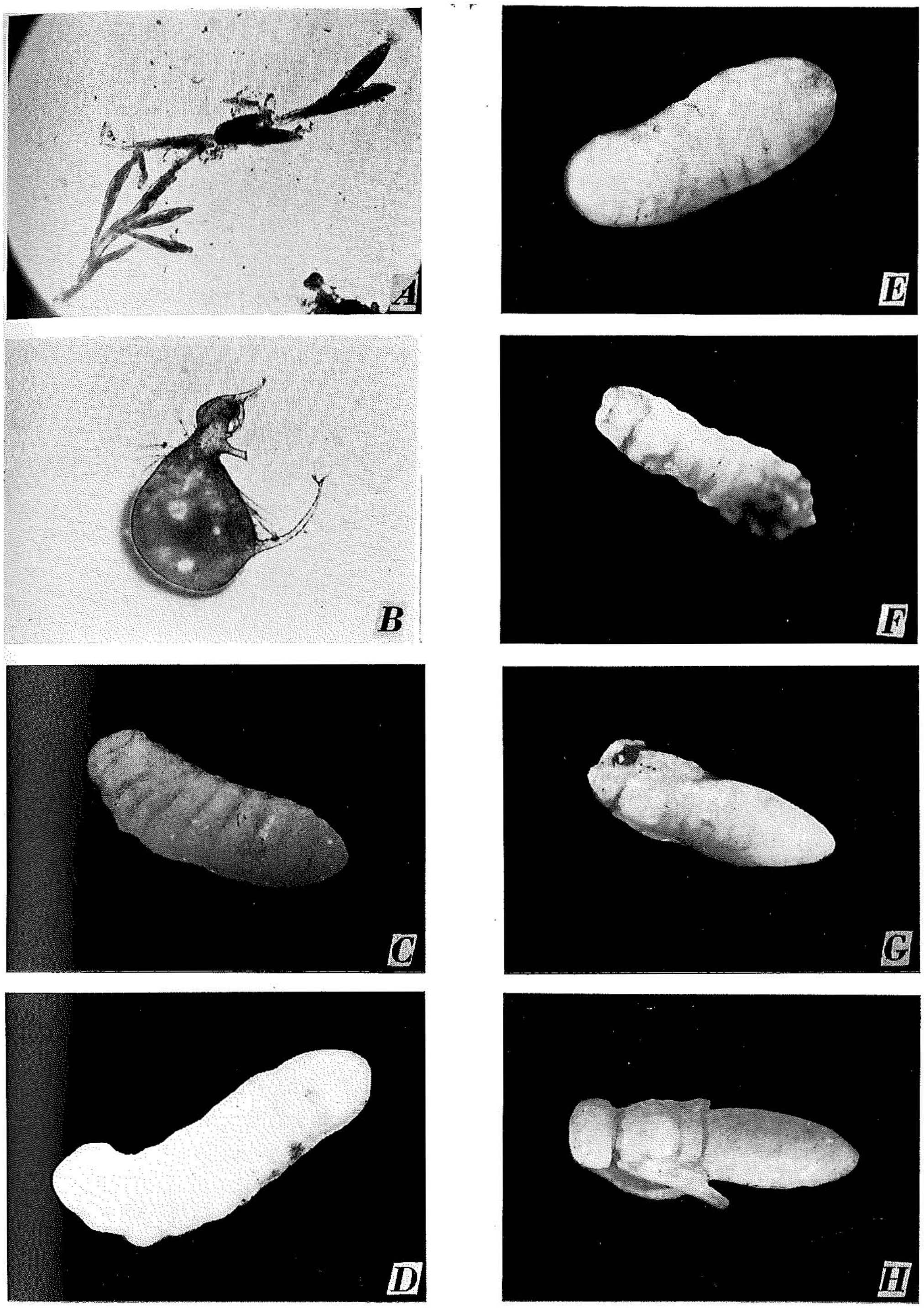


Plate Ⅲ. *Scelio tsuruokensis* WATANABE

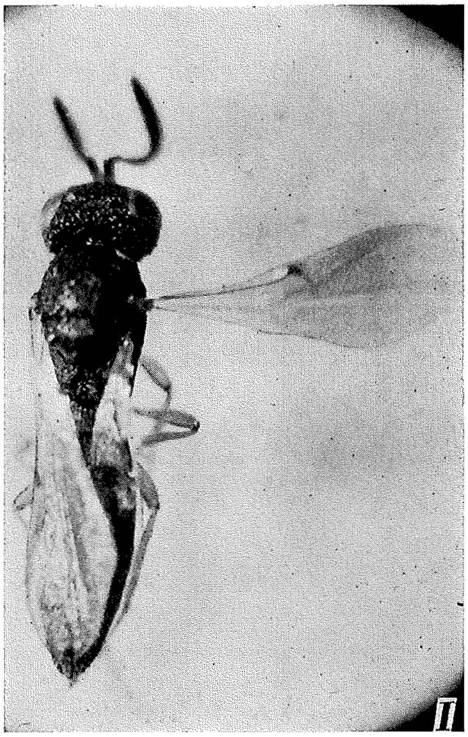


Plate Ⅳ. *Scelio tsuruokensis* WATANABE